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GROWTH IN ORGANISMS¹

THE main proposals discussed in this address were as follows:

1. The development of an organism from the spore or embryonic stage includes the two processes of auxesis or enlargement and of differentiation both in the single cells or elements and in the organs.

2. The present studies are based upon the conception that living matter is composed mainly of pentosans and albumins or albumin derivatives with lipins as a minor component. The proportion of the main components may vary from nearly a hundred per cent. to nearly zero.

3. The principal and characteristic substances of the two groups are practically non-diffusible and hence come together only as an intimate mixture in a colloidal condition, with varying arrangement.

4. Growth of living matter consists of hydration with accompanying swelling and of accretion of solid matter, the two processes being actually independent.

5. The hydration of the substances belonging to the two main components is affected in an opposite manner by hydrogen ions, and is variously modified by temperature and other conditions: the rate and amount of growth is a resultant of several reactions.

6. Accretions of new material include the absorption of salts which tend to restrict hydration and the incorporation of amino-compounds. So-called nutrient salts do not constitute food but may act as catalysts or releasers of energy in other substances and as controls.

7. The enlargement of cells is almost entirely by the swelling which results from hy-

¹ Presidential address, Pacific Division of the American Association for the Advancement of Science meeting at Pasadena, June 19, 1919. Manuscript abbreviated by the author.

dration in their earlier stages, and later the enlargement of the syneretic cavities in the colloidal structure is followed by the distending or stretching action of osmotic pressures in the vacuoles thus formed.

8. Illustrations by records of growth of leafy stems, joints of cacti, fruits of *Solanum* and trunks of trees.

The development of an organism from the single- or few-celled stage to the stature of the adult individual is generally characterized as growth. One of the first facts that comes to the notice of the observer who follows the life history of an animal or plant from the egg or the spore or from the resting stage in a seed to maturity is that all parts of the individual do not enlarge at the same rate, and that if attention be fixed upon the most readily available object for such a study, the root or shoot of any plant, it will be seen that the power of expansion seems to reside only in the region of the tip in the case of the root and in the tip and in certain regions in the younger internodes of stems, while such organs as the leaves of grass elongate by the action of a growing zone at the bases. There are of course many specializations of this action such as those displayed by simple organisms in which a single cell is the individual and when this reaches full size all possible growth is accomplished. As our principal purpose in the present discussion is to present the action of the protoplasm in growth it has been found most convenient to use facts discovered by the measurement and analyses of plants consisting of many millions of cells.

With magnifications of much less than a hundred, we readily see that the embryonic cells of a plant which may be imagined as of a cubical or prismatic form and consisting of a dense mass of colloidal matter, become larger, that they also change form, show new structures in the mass and that the enclosing wall takes on a variety of forms. These changes determine the final part which the maturing cell may play in the complex processes of the organism. The architecture of the plant includes many beautiful mechanical designs and it would be well to guard against

the error of considering it as simply a set of sacs, test tubes, and bits of jelly by recalling the fact that it is, like all living things, an engine which not only picks up its fuel, manufactures it into briquettes, or their physiological equivalent, burns this fuel, the derived energy being used in a variety of ways, but while this is going on the machine is also adding to, repairing and altering its own parts. This, however, does not imply that any special or mysterious "life forces" are concerned. The physiologist may in fact identify a large number of the things that may happen in the cell and he may imitate many of them and the progress of science will be marked by the successive subjugation of others, but to assemble the material in a way to obtain the complexity and the sequences of reactions of living matter is beyond our capacity for manipulation, and our failure may not be ascribed to the lack of any elusive vital spark.

The taste for polysyllabic definitions of protoplasm has waned and we are not so much concerned with inclusive descriptions as with an understanding of the nature of the substances which enter into its composition and how these react when subjected to conditions which may prevail in the cell. Protoplasm when viewed with a low power microscope appears to be a silvery translucent mass of material like a highly hydrated jelly, which, in fact it really is, being composed of about one to two parts of solid matter to about two hundred of water. The constituency of the solid part, or the residue which is obtained by driving off all of the water is a matter of no little interest, since it is upon this physical basis that all of the properties of the organism rest.

The proteins or albumins are invariably present, and the transformations in the highly complex molecules of the nitrogenous compounds in living matter offer some tremendous difficulties in interpretation and at the same time yield the material for some of the most romantic chapters in biological science. Present in every cell, these substances may not move from one protoplast to another ex-

cept in the highly hydrated state known as peptones, or when broken apart into comparatively simple amino-compounds. Gelatine, a substance of an albuminous character, has been widely used in experimental work which had for its purpose the determination of the properties of living matter, but we are now so far advanced as to know that it may represent the qualities of the protoplast only in so far as these may be identical with amphoteric compounds. In other words, the behavior of gelatine may be used to some extent to simulate the reactions of protoplasm which consists largely of albuminous substances. This is not a universal condition and in fact is the exception in plants.

Lipins or fatty substances form an important part of the living matter of animals and in their growing cells may constitute as much as two per cent. of the solid matter, amounting to one part in a thousand of the total weight. The lipins may unite with phosphoric acid, with carbohydrates, or with nitrogenous substances such as the amino-acids; giving diverse materials, the action of which in the life processes is but dimly comprehended.

The physiologist who devotes himself to the study of life as exemplified by animal forms deals with a protoplasm in which the proteins and lipins predominate, and is excusably apt to believe in the universality of the properties he uncovers by a study of their reactions. The presence of mucin, gums and mucilages in living matter has long been known, but the determination of their definite occurrence as a component part of the mechanism of the cell was first accomplished at the Desert Laboratory. Numerous analyses show that the pentoses and their condensation products the pentosans are abundant in plant cells, and that they may form a larger proportion of its dry weight than do the proteins or nitrogenous substances.

Here however, we must avoid the mistakes of our predecessors by assuming a universal condition. Specialized organs or cells, eggs, spores, pollen cells, etc., may have a protoplasm in which the protein material may make up almost the entire solid matter, and

at the same time it is not to be assumed that the main components are evenly distributed throughout the mass of the protoplast, as it is very well known that the nucleus and other special organs of the cell are high in albumins. Consultation of available information on this point shows that in bacteria for example over 90 per cent. of the solid matter may be albuminous. The analyses of cacti made by Dr. H. A. Spoehr at the Desert Laboratory show that not more than a tenth of the living matter is proteinaceous, and that the greater part of the cell content is carbohydrate, pentosans, of which gum arabic, tragacanth, mucilage and agar are common examples, these being in fact combinations of the simpler pentose and hexose sugars.

Miss Stewart of Barnard College has recently described the manner in which pentosans formed in the cytoplasm accumulate in a layer next the wall leading some observers to believe mistakenly that they were formed by the hydrolysis of wall material. In other cases masses were formed in cavities in the protoplasm. Gross chemical analyses determine the presence of such substances in material in which they occur only in finely divided form in the colloidal mixture and may not be detected by microchemical methods. At present our knowledge of these substances is confined chiefly to their action as a part of the hydration or growth mechanism, and it is by no means clear that they are not more or less included in the metabolic cycle.

These statements are not to be taken as implying a simple composition for protoplasm: The different and various pentosans on the one hand and the amino-compounds built up by the plant or derived from albumins have various special characters although the first agree in being weak acids, and the second are amphoteric, capable of acting as either acids or bases according to conditions. As an example of these differences there has been much discussion as to whether or not protoplasm was soluble or miscible in water. It is obvious that living matter in which the pentosan was a mucilage like gum arabic would be miscible with water, while a pentosan like

tragacanth would be less soluble, and a group like agar, for example, would not appear to be soluble at all. It is by no means implied that solubility invariably depends upon differences in the carbohydrate component as it might also result from the character of the amino-compounds or proteins present, especially in a protoplasm rich in nitrogen.

My studies of growth have been carried out on the assumption that the principal features of importance are those which might be due to the reactions of the carbohydrates and of the proteins which may be present. It is in order therefore to inquire into the condition in which these substances may occur in living matter particularly with respect to their relation to each other. The first and most important relation to be considered is the fact that the mucilages or pentosans and the albumins of amino-compounds of the cell may diffuse into each other very slowly or not at all. Their joint presence in living matter is in a condition in which they are intimately mixed in a colloidal condition. Molecules or groups of molecules of each lie side by side with various possible arrangements. Thus it is conceivable that the mucilage of a cell might be in the form of a mesh or honeycomb with the proteins forming droplets enclosed in the continuous structure, or the reverse might be the case; again substances of both groups might each form a continuous meshwork interlocking with the other, and another category of variables would be introduced by the lipins which might be interposed or incorporated in these systems. Living matter probably does not remain fixed in any one of these simple arrangements, or in any one of a dozen others which might be described if space permitted, and the suggestion is ventured that the play of molecular force where aggregates of a different kind are in contact may constitute the essential and characteristic action of living matter.

Let us now fasten attention upon the theoretical final structure of protoplasm and endeavor to construct for ourselves a mode or plan of action which might be followed in its growth. Growth as has been defined con-

sists of two processes. First the molecules or aggregates of molecules of the two kinds, the carbohydrates and the albumins, combine with and absorb water, thus increasing the volume of these units regardless of whether such molecules be in the form of droplets or fibrillæ of a meshwork. Instances of growth are known in which water only has been added to the colloidal structure in which in all probability the solid particles have been variously rearranged. In general however growth is accompanied by the accretion of molecules of solid material in such manner that as development proceeds their proportion to that of the water taken increases and organs are then said to show an increase of relative dry weight with age.

On the other hand, my own studies have shown that succulent organs or stems, such as leaves of the Crassulaceæ, joints of cacti, fruits, etc., do not show such increase and the proportion of solid matter and of water undergo but little change, their incorporation being at a rate which keeps them near the initial proportion. It is suggested that such action may be shown by the fleshy fungi although I have not seen any data bearing directly upon this matter.

The conditions under which hydration may ensue are by no means identical for the two main constituents of living matter. Thus the albumins and their derivatives as exemplified by the behavior of gelatine show a swelling determined or facilitated by the hydrogen ion concentration or acidity of the solutions, being increased as this rises. The pentosans, on the other hand, show no such increase, and being weak acids, their hydration is retarded by the hydrogen ion. The swelling of a mixture of the two will therefore be a resultant of these effects and of the proportion of the two elements in the living mixture, and as the unceasing action of respiratory metabolism results in the formation of some residues of acids, the condition of hydration of any mass of protoplasm may be said to reach a volume determined by these opposed reactions. The effects in question may be illustrated by the citation of my experiments, in which gelatine

was found to show a swelling in hundredth normal acetic acid fifty per cent. greater than in distilled water, agar forty per cent. less, and a combination of eight parts of agar and two parts of albumin, about forty per cent. less than in water.

The hydrogen ion concentration of the fluids in a plant cell are controlled by the buffer conditions which exist there, but still the range of variation is much wider than that found in the circulatory systems of animals. Bases or cations are seen to affect the swelling of the plasmatic mixtures in my experiments. Various authors having secured results indicative of accelerating effects of certain amino-compounds on growth, some swelling tests of the effects of these substances were made with the discovery that such an amino-acid as glycocoll in hundredth molar solutions seems to retard the swelling of gelatine, at least when the increase in thin dried plates is considered, and to accelerate the swelling of agar to and beyond the total in water. The mixture of agar and albumin, as well as a mixture of agar and gelatine, shows a greater hydration in glycocoll than in water.

The possible physiological significance of these results is heightened by the knowledge of the fact that some of these amino-compounds may be taken to be universally present in growing cells and they probably vary less than the organic acids. It is suggested that the ammonia group in these compounds may form a salt with the carbohydrates with the effect of increasing the hydration capacity. Whether any reaction with, or effect upon, the hydration of the protein element occurs is not yet clear, although it is obvious that such action might be of fundamental importance in nutritive metabolism. The entire matter of hydration may be briefly summarized by the statement that the fundamental properties of a colloidal mixture or of living matter will depend upon the proportion of albumins and of pentosans, and upon the properties of the particular substances of each group which may be present. Hydrogen ions within the possible range of concentration increases hydration of the albuminous substances and depress that of

the pentosans. Bases or cations exert a reverse effect on the albuminous substances and depress hydration of the pentosans slightly. Certain amino-compounds depress the swelling of albuminous compounds, but facilitate the hydration of pentosans and sections of such substances when mixed in a proportion of four to one with albumin undergo hydration to a degree equivalent to or even greater than that in water.

The second phase of growth, that of the incorporation of molecules of solid matter is not so easily described since it is not so directly susceptible of experimental test. If the conception of the pentosan-albumin composition of protoplasm is correct, it is obvious that the mass of living matter may not be increased simply by the addition or diffusion of sugars into the meshwork, as is supposed by some writers.

Before the material in these carbohydrates may actually become a part of the colloidal living mesh it is undoubtedly broken down to some extent by enzymatic or respiratory action, part of the material being carried through transformations to organic acids or carbon dioxide, some of the material is combined with the ammonia group (NH_2) to form amino-compounds, some with the lipins, while some of these sugars may be converted to the pentose form in which they would so markedly affect the hydration capacity of the mass.

By way of crude illustration, protoplasm might be regarded as the wick of a lamp which draws sugar into its meshes, burns the sugar and in the burning some of the sugar not completely consumed unites with other substances to form additional fibers of the wick.

At this point it would be well to divert attention for the moment to the so-called "nutrient" salts, the presence of which in the soil and in the liquids of the plant is so indispensable to the plant. It is necessary for an understanding of the real nature of growth to have clearly in mind that living matter is a colloidal mixture of proteins and carbohydrates, which takes up water and gains solid material in growth by processes which are actually retarded by these salts. These com-

pounds in fact yield no energy and furnish no building material. They may act as catalyzers or as releasing agents, and as controls of water absorption or as guides in colloidal arrangement, but they are not "food-material" in any sense. The constituents of fertilizers should be designated as "culture salts" and as such have all of the importance which has been imputed to them; a determination of the composition and proportion of salts in a culture solution which will induce maximum production of grain, fruit or forage is a problem of the first rank now happily receiving something like an adequate investigation.

The foregoing suffices to account for the mechanics of growth or expansion of a single-celled or naked organism. The development of complex, massive or higher organisms especially in plants, however, is accompanied by the formation or deposition of an outer layer of denser consistency which occurs at any phase boundary of colloidal material. This membrane so-called is in any case a product of the surface energy of the mass or system of living material in the cell and of the material in contact and its constitution, and even its structure must vary as widely as that of the protoplasm which produces it.

External to the membrane is the cell-wall which begins to be formed around plant cells as soon as they divide or are separated and this wall increases in rigidity and offers greater resistance to stretching as it grows older.

The arrangement in question, therefore, is one in which the expanding and growing protoplast is enclosed in a sac or bag of its own making and which acts as a screen not only in allowing some materials to pass while others are shut out, but also is so constructed that some solutions pass through it more readily into the cell than out of it, these being simply examples of some of the many facts discussed under the designation of permeability. The external screening membrane takes on a special significance in connection with the osmotic action of the vacuoles.

These sacs were at one time thought to have a morphological value, but it is now understood that almost any hydrating colloidal mass

may exhibit syneresis in which cavities or canals are formed in which the colloidal material accumulates in an attenuated or liquid condition. These syneretic cavities increase by absorption of water and by the time the protoplasm of the cell has attained about half of its ultimate bulk in some instances, these cavities have enlarged to occupy a space as large as the protoplasm and acting as vacuoles by which they are ordinarily known, eventually fill a much larger space. The expansion of these vacuoles and the consequent increase in volume of the cell constitutes part of the enlarging action of growth, and this expansion takes place by the force of osmotic action, and the result of such stretching is to set up a tension ordinarily designated as turgidity. The vacuoles continue to hold some of the colloidal material and may also carry in solution almost any substance in the cell which may be passed into them by osmosis or diffusion, including sugars, salts, acids, amino-compounds, etc.

The enlargement of the individual masses of living cells in organisms entails a certain amount of work which in the earlier stages is derived almost entirely from imbibition or adsorption, and while such action continues throughout the growth or life of the living matter, there is in addition the stretching action exerted by the expanding vacuoles by osmotic action. The growing regions or plants at all times include cells in all of these stages, from the newly separated protoplasm which is expanding entirely by imbibition of water and incorporation of new material, others in which the syneretically formed vacuoles are increasing and thus adding to the volume of the cell by osmotic action, and others approaching maturity in which the vacuole may have attained such size as to occupy many times the space of the living matter which may indeed now be but a sac with its layers of irregular thickness lying internal to the wall, which now has become dense and rigid.

The measurement of the growth of a stem, root or fruit of a plant will, therefore, show the composite changes in volume of cell masses

in all of these stages, and consequently express the action of imbibition and osmosis.

The distinct action of imbibition and the later joint action of hydration by osmosis and by imbibition may be most readily recognized, in organs in which the region of growth is generalized as in the ovate flattened joints of *Opuntia* or in such globular fruits as the tomato. The measurement of the growth of one of these joints may be begun when it has a lateral area no larger than the thumbnail, and during this stage the increase is rapid and shows a minimum disturbance from changes in external conditions, as shown by the illustrations. Growth continues throughout the entire mass until an advanced stage of development is reached, when it first slackens in the basal portion. By this time large vacuoles have been formed in the thin-walled cells, and water loss from the surfaces of the organ has reached such a rate that great daily variation in the volume results and actual shrinkage may ensue. A similar history may be predicated for such structures as the large berry-like fruit of the tomato, it being noted that the material in both illustrations takes on solid matter and water at such rate that not much alteration in their proportions occurs during development.

The enlargement of the trunk of a tree results from the multiplication and growth of cambium and other cells on the outside of the trunk directly inside and covered by the bark. The trunk of the tree is in effect a cylinder of moist but dead woody tissue surrounded by a living sheath which becomes very active at some time in the year and which as a result forms an additional layer or sheet of wood on the trunk which in cross section gives the appearance which has caused it to be designated as an annual ring of growth.

The actual course of growth or formation of these annual cylinders or, more strictly speaking, cones, has not until recently been measured. In 1918 I was successful in making a working model of a dendrograph which might be attached to the trunk of a tree in such manner that its changes in volume due to whatever causes were traced on a ruled sheet of paper carried by a revolving drum. The

essential part of this apparatus is a yoke of metal, which has two bearing screws resting on the trunk and carrying a third contact point on the end of the pen lever. It was not possible to make a practicable instrument until a yoke could be constructed which showed but little variation as a result of changes in temperature. Three alloys with a very low temperature coefficient, bario C., manganin and invar have been used and dendrographs are now in operation on the trunks of two species of pine, and oak, an ash, a sycamore and a beech tree, and as these instruments were placed in position before growth began in 1919, there is every prospect that seasonal records will be obtained from which the principal features of growth may be seen. Weekly records show that these trees do not behave alike and that many conditions are to be considered in interpreting the records.

It is evident for example that but little is known concerning the properties of bark as a water-proofing or protecting coat for the tree. The loose bark of the ash and pine trees seems to allow such a great water loss from the surface during the mid-day period as to cause actual shrinkage which does not occur in trees such as the beech and live-oak, which have a perfect living green outer bark or skin. The facts disclosed by these records can not fail to be of interest in a discussion of any phase of the complicated problem of the ascent of sap.

D. T. MACDOUGAL

DESERT BOTANICAL LABORATORY

JOSEPH BARRELL

AMERICAN geology has lost one of its foremost leaders, one who promised to stand as high as the highest. Professor Barrell's other colleagues will undoubtedly agree with Professor T. C. Chamberlin when he says: "We had come to look upon him as one of the most promising leaders in the deeper problems of earth science. We feel that his early departure is a very sad loss to our profession not only, but to the whole group of sciences that center in the earth and its constitution."

Only a few days before his death there came to him the news of the highest honor that can be given to an American scientist, election to the National Academy of Sciences. His election, furthermore, was by a unanimous vote of the academicians present at the April meeting in Washington, and such a vote is rare in the academy.

Joseph Barrell, the son of a farmer, was born at New Providence, N. J., December 15, 1869, and died of pneumonia and spinal meningitis in New Haven on May 4, 1919. He leaves a wife and four sons. Standing 5 feet 10.5 inches in height, of the blue-eyed Nordic type, with a full head of wavy light-brown hair, he was spare and slender in build, but characterized by great muscular strength in comparison to body weight. He was of the eighth American generation from the Puritan George Barrell, who migrated from Suffolk, England, and settled at Boston in 1637. This first American Barrell began as a cooper, but most of his descendants have been sea-going people and shipping merchants. The most widely known and wealthiest was Joseph Barrell of Boston, after whom the subject of our sketch, his great-grandson, was named. This Joseph Barrell is said to have "early espoused and firmly maintained the cause of his country," and for a time represented the town of Boston in the State Legislature. It was in his splendid home that General George Washington was entertained during his visit to Boston.

Professor Barrell received the first part of his collegiate education at Lehigh University, taking in due course its B.S., E.M. and M.S. degrees, and in 1916 this institution gave him its doctorate of science. From 1893 to 1897 he was instructor in mining and metallurgy at his alma mater, and then was given leave of absence to go to Yale for graduate studies in geology, taking his Ph.D. degree in 1900. Returning to Lehigh, he was made assistant professor of geology, and for three years taught not only geology but zoology as well. In 1903 he was called to Yale as assistant professor of geology and in 1908 promoted to the chair in structural geology. In the geological department at Yale he was a unifying force

and a tower of strength. During the summer months from 1893 onward, Barrell spent nearly all the time in the field, working at first as an engineer in the coal mines of Pennsylvania, then in the mines of Butte, Montana, devoting one summer to the geology of southern Europe, and later studying widely the geology of the Appalachians and of the New England States.

Professor Barrell's first publications, in 1899 to 1900, deal with mining, but since 1901 nearly all his work has been in geology. His bibliography has upward of forty-five titles, totalling more than 1,500 pages. Several articles remain unpublished, at least two of which it is hoped to print during this year. A more detailed account of his life and work will appear in an autumn number of the *American Journal of Science*.

Barrell's most important work has to do with the strength of the earth's crust. The series of papers bearing that title examine into "the mechanics of the earth considered as a body under stress, owing to the variation in density and form which mark its outer shell." He was all the more able to handle this most difficult subject because of his thorough training in engineering at Lehigh. His last work along this line will be published this fall. From the manuscript we learn that "The larger features of the earth's surface are sustained in solid flotation, and at some depth the strains due to the unequal elevations largely disappear, the elevations being compensated by variations of density within the crust. In consequence, the subcrustal shell is subjected to but little else than hydrostatic pressure." Isostatic balance is, however, not everywhere in adjustment, but the adjustments are held to be irregular and imperfect in distribution and mostly concentrated in the outer one hundredth of the earth's radius, with a tendency to progressively disappear with depth. On the other hand, "the outer crust is very strong, capable of supporting individual mountains, limited mountain ranges, and erosion features of corresponding magnitude."

Barrell also did much toward working out the criteria by which the climates, marine

deltas and geographies of the geologic past may be discerned in the sediments or stratified rocks that make up the greater portion of the geologic record. This work brings out especially the importance in earth history of the ancient formations laid down upon the lands by the fresh waters and the wind, in contradistinction to those deposited by the seas and oceans.

The length of geologic time was another problem that deeply interested Barrell. In his "Rhythms and the Measurements of Geologic Time," he came to the conclusion that through the rhythmic oscillations of the terrestrial processes which the earth has undergone, its age is many times greater than even geologists in general have imagined—in fact, that it is of the order of about 1,500 million years.

A fourth line of research which occupied Barrell was the origin and genesis of the earth, and here he extended in modified form the Chamberlin-Moulton planetesimal hypothesis, *i. e.*, that the planets and their moons arose out of the sun during a time of induced tidal disruption. Some of his best work was to develop along this line, and an extensive manuscript on "The Genesis of the Earth" is ready for publication.

Since 1913, Barrell has on a number of occasions taken opportunity to point out that the supposed Mesozoic peneplain of southern New England was in reality "stairlike or terraced in its character, facing the sea, and bore the marks of ultimate control by marine denudation. These terraces [more than five in number] are now dismantled by erosion except in regions favored by the presence of broadly developed resistant rock structures. . . . All are regarded as younger than the Miocene." With this view, he adds, we get "a suggestion of the geological rapidity of completion of an erosion cycle in a region near the sea and of a sequence of diastrophic rhythms there recorded." Here too there is considerable manuscript that will be published later on.

Finally, the evolutionary problems connected with paleontology claimed his interest, and he has presented evidence to show that fishes probably arose in the early Paleozoic in

the fresh waters of the lands, and thence migrated to the seas. Also that lungs developed out of air-bladders in water-breathing animals caught in recurrent epochs of semi-aridity. Such great environmental changes brought about the necessity for change from a water habitat to seasonal dry ones, and hence "the piscine fauna which endured these conditions came through profoundly changed." The primitive sharks of Silurian time, having no air-bladder, "were driven to the seas. The fresh-water fishes which remained were ganoids and dipnoans, fishes with air-bladders efficient for the direct use of air." Finally, from cross-opterygian ganoids, under the stimulus of the semiaridity of the Devonian, there emerged the amphibians, able to carry forward their activities as terrestrial animals.

Similarly, he held that man was brought to his present high physical and mental state not merely as the "product of time and life," but that he is "peculiarly a child of the earth and is born of her vicissitudes." The changing climates during the Pliocene and Pleistocene, acting upon the vegetation of these times, caused the prevalent forests of Asia, he thinks, to dwindle away, producing "a rigorous natural selection which transformed an ape, largely arboreal and frugivorous in habits, into a powerful, terrestrial, bipedal primate, largely carnivorous in habit, banding together in the struggle for existence, and by that means achieving success in chase and war. The gradual elimination, first of the food of the forests, lastly of the refuge of the trees, through increasing semiaridity, would have been a compelling cause as mandatory as the semiaridity which compelled the emergence of vertebrates from the waters, transforming fishes into amphibians."

CHARLES SCHUCHERT

YALE UNIVERSITY

SCIENTIFIC EVENTS

THE SOLAR ECLIPSE¹

TELEGRAMS received by the Astronomer Royal report that at the station at Sobral, in Brazil, occupied by Dr. Crommelin and Mr.

¹ From *Nature*.

Davidson for photographing the field of stars round the sun on the occasion of the total eclipse of the sun last week (May 29), the sky was clear for at least part of totality, and that the program was satisfactorily carried out. The photographs have been developed, and all the stars expected are shown on the plates taken with the astrographic lens, as well as on those taken with a second telescope lent by Father Cortie. The expedition will remain at Sobral until the necessary comparison photographs are taken *in situ*. The message from Professor Eddington at Prince's Island, off the coast of West Africa, which reads "Through cloud, hopeful," may be taken to imply that some success will also be derived from the work of this expedition.

It will be remembered that Professor Eddington and Mr. Cottingham were provided with the 13-inch object-glass of the astrographic telescope of the Oxford University Observatory, whilst the observers in Brazil had the similar object-glass from Greenwich, and that the program of both stations was to take photographs of the stars that surrounded the sun, of which there are at least twelve within $190'$ of the sun's center of photographic magnitude ranging from 4.5 to 7.0, for the purpose of testing Einstein's relativity theory of gravitation, and also the hypothesis that gravitation, in the generally accepted sense, acts on light. Photographs that have been taken during the eclipse will be compared with others that have been, or will be, taken of the same stars in the night sky to detect any displacement that may be considered to be due to the presence of the sun in the field.

There is at present no information as to the type of the corona, and apparently few observing parties have been organized to make observations to record this. From a note in the daily press last week, said to emanate from the Yerkes Observatory, it seems not unlikely that a large prominence may have been on the limb of the sun at the time of the eclipse.

It had been announced that the Cordoba Observatory would dispatch an expedition to Brazil, and that possibly Professor Abbot, of the Smithsonian Institution, would proceed to

La Paz, Bolivia, where the eclipse happened at sunrise, with coronal cameras and with instruments for measuring the sky radiations by day and night, but it is too early to have heard of any results of such observations. Also it has been announced that Professor D. P. Todd would take photographs of the eclipse from an aeroplane at a height of 10,000 feet from the neighborhood of Monte Video, where the eclipse would only be partial.

REVISTA MATEMATICA HISPANO-AMERICANA

UNDER the above title a new mathematical periodical began to appear at the beginning of the present year, which may be of some general scientific interest both on account of territory covered by its title and also on account of some of its unique aims. One of these is the publication of corrections of errors found anywhere in the mathematical literature. These corrections are to appear in a special section headed *Glosario Matematico*.

While mathematics is an exact science its literature is by no means free from different types of errors, varying from slight oversights to those relating to matters of fundamental importance. The majority of these errors are readily recognized by the careful reader and need only to be pointed out to be acknowledged; but, as mathematics grades gradually into various inexact sciences—such as philosophy, history and physics—it is clear that a part of its literature relates to the eternal approximations towards an unstable limit and here the question of errors connects up with endless words.

The corrections in the *Revista*, published at Santa Teresa, 8, Madrid, Spain, are supposed to be confined to the former type of errors and these corrections may serve the double purpose of curtailing the repetition of such errors and of pointing out somewhat slippery ground in mathematical fields. It is also of interest to walk securely over ground where experts slipped by overlooking lurking dangers which their slipping caused to change to well-marked pitfalls.

General interest in this new mathematical periodical may perhaps be enlisted by the can-

did manner in which the unfavorable mathematical situation among the Spanish-speaking people is depicted in a short note appearing in the first number of this journal. The comparatively slight contributions made by these people along the line of mathematical research stands in great contrast with the large advances made by the people living immediately north of Spain.

One of the most important steps towards the remedy of an unfortunate public situation is to exhibit the great need of such a remedy. It is hoped that the present journal may be successful in this direction and also in awakening interest in a field which is so fundamental for the further scientific development of the people using the Spanish language. The editor of the journal is J. Rey Pastor.

G. A. MILLER

EXPEDITIONS OF THE CALIFORNIA ACADEMY OF SCIENCES

MISS ALICE EASTWOOD, curator of botany, of the California Academy of Sciences, has just returned from a three months' study of the flora of Arizona and New Mexico. Miss Eastwood's special mission was to collect trees and shrubs but chiefly cottonwoods for Professor C. S. Sargent of the Arnold Arboretum in connection with the revision of his *Trees of North America*. At the same time Miss Eastwood made important additions to the herbarium of the academy.

The academy is undertaking exploration work this summer in lower California. Mr. Joseph R. Slevin, assistant curator of the department of herpetology, sailed on June 14 on the steamer *Alliance* for La Paz, Mexico, with the purpose of investigating the reptiles and amphibians of the cape region of the peninsula. Mr. Slevin is accompanied by Mr. Gordon F. Ferris, instructor in entomology of Stanford University. Mr. Ferris is commissioned by Stanford University to make a special study of the scale insects of the region and will also collect for the departments of entomology and invertebrate zoology of the California Academy of Sciences. This work will be chiefly in the lower third of the peninsula and will require about three months time.

Dr. Roy E. Dickerson, honorary curator of the Department of Invertebrate Paleontology, sailed May 31 with Mrs. Dickerson for Manila, Philippine Islands. Dr. Dickerson will make an investigation of the Philippine Islands with a view to the location of oil deposits. During Dr. Dickerson's connection with the California Academy of Sciences as curator of the department of invertebrate paleontology important research work was carried on in the geology of the Pacific coast area, which received publication in the *Proceedings* of the academy. These papers are much in demand at present by the commercial interests engaged in oil production.

FOREIGN DELEGATES AND GUESTS AT THE ATLANTIC CITY MEETING OF THE AMERICAN MEDICAL ASSOCIATION

PHYSICIANS from fourteen foreign countries were in attendance at the meeting. Apart from Canadians they were as follows:

Lehman, Wilmer S., Lolodorf, Cameroon, W. Africa.
 Casier, Baron Ernest, Belgium.
 Depage, Antoine, Belgium.
 Duesberg, J., Belgium.
 Melis, L., Brussels, Belgium.
 Nolf, P., Brussels, Belgium.
 Sand, René, Brussels, Belgium.
 Captain Van de Velde, Belgium.
 Chutro, Pedro, Buenos Aires.
 Lee, S. T., Peking, China.
 Leonard, Eliza E., Peking, China.
 Ming-Shao, Hsu, China.
 Peter, William Wesley, Shanghai, China.
 Ting-han, Chang, China.
 Almila, E., Havana, Cuba.
 Carrera, Julio, Cuba.
 Fernandez, Francisco M., Havana, Cuba.
 Guiteras, Juan, Cuba.
 Martinez, Emilo, Cuba.
 Somodevilla, Santiago U., San Luis, Cuba.
 Kingman, E. L., Zaruma, Ecuador.
 Brown, W. Herbert, Glasgow, Scotland.
 Dimsey, Edgar R., British Admiralty.
 Groves, Ernest W. Hey, England.
 Hurst, Arthur F., England.
 Lane, Sir William Arbuthnot, England.
 Murphy, Shirley, England.
 Newsholme, Sir Arthur, England.
 Rose, Frank A., London, England.

Thompson, Sir St. Clair, London, England.
 Bégouin, Paul, Bordeaux, France.
 Lemaître, Fernand, France.
 Picqué, Robert, Bordeaux, France.
 Alexion, Alexander, Greece.
 Constas, John, Greece.
 Allen, Belle Jane, Baroda, India.
 Fletcher, A. G., Taiku, Japan.
 Kamaimura, Asajiro, Tokio, Japan.
 Kodama, Ryuzo, Japan.
 Uchimo, Senichi, Tokio, Japan.
 Holst, Peter F., Norway.
 Muro, Felipe, Lima, Peru.
 Ingvar, Sven, Lund, Sweden.

HONORARY DEGREES AT YALE UNIVERSITY

At the commencement exercises on June 18 Dr. Theodore Salisbury Woolsey, professor of international law, emeritus, in presenting candidates for honorary degrees said as public orator:

MASTER OF ARTS

Orville Wright: The survivor of two brothers who by their mechanical skill, ceaseless experimentation and accumulated knowledge of physics, have led the way in mastering human flight. The inventive genius of Mr. Wright in a brief sixteen years has filled the sky with its creations, has changed the methods of warfare, has captivated the youth of all lands and now ventures to cross the ocean.

Samuel Hosea Wadhams: A graduate of Sheffield, in 1894, a surgeon in the regular army, serving in the Spanish War, early sent to France as an observer, placed later on the General Staff, in tact, in vision, in ability pre-eminent, Colonel Wadhams, more than any one else, has shaped the policy of his department. During our share in the war, he has borne the entire responsibility for the wounded in the battle area, has won the admiration of his fellow workers and has earned the honor which his university desires to pay.

DOCTOR OF SCIENCE

Samuel Wesley Stratton: Mathematician, physicist, professor in the Universities of Illinois and Chicago, a naval officer in the Spanish war, since 1901 director of the National Bureau of Standards in weight and measures.

Dr. Stratton's work in this bureau has been conspicuous and constructive, recognized beyond our own limits, vitally important in war and war research. A man weighed in the balance and not found wanting.

Harvey Cushing: Son of Yale and Harvard professor, a leader in the new field of neurological surgery, in operations of the brain pre-eminent, surgeon in chief of the model Brigham Hospital, honored at home and abroad. Colonel Cushing served with the French in 1915 and 1917, with the British at Messines and Passchaendaele, being mentioned in dispatches. At this time organizing intensive study of penetrative skull wounds, he reduced their mortality by one half. Under our own flag he became chief consultant in neurological surgery for the A. E. F. A gentleman, a bold investigator, an artist in the operative field.

SCIENTIFIC NOTES AND NEWS

PRINCETON UNIVERSITY has conferred the doctorate of science on Dr. John M. Clarke, director of the State Museum of New York, and the degree of master of arts on Mr. Lester E. Jones, director of the U. S. Coast and Geodetic Survey.

DR. DAVID F. HOUSTON, secretary of agriculture, has received the degree of LL.D. from Brown University.

THE honorary degree of doctor of science has been conferred upon Dr. Raymond Foss Bacon, director of the Mellon Institute of Industrial Research, by De Pauw University.

ON the occasion of the annual commencement of the University of Pittsburgh on June 13, the honorary degree of doctor of engineering was conferred upon Mr. Vannoy H. Manning, director of the United States Bureau of Mines, in recognition of his noteworthy accomplishments in the investigation of problems of mineral technology. The university also conferred the honorary degree of doctor of chemistry upon Dr. Willis R. Whitney, director of the Research Laboratory of the General Electric Company, Schenectady, New York, because of the valuable service which he rendered to the government as a member of the

Naval Consulting Board. These honorary degrees were given upon the recommendation of the Mellon Institute of Industrial Research, an integral part of the University of Pittsburgh.

DURHAM UNIVERSITY has conferred its doctorate of science on Sir E. Rutherford, Sir G. T. Beilby, Professor A. A. Herdman and Professor J. J. Welsh.

SIR J. J. THOMSON has been appointed a member of the advisory council to the committee of the privy council for scientific and industrial research.

DR. GISBERT KAPP is about to resign the professorship of electrical engineering in the University of Birmingham.

PROFESSOR Robert W. Wilson has retired from the chair of astronomy at Harvard University.

THE Royal Society of Arts, London, has awarded its Albert medal for 1919 to Sir Oliver Lodge "in recognition of his work as the pioneer of wireless telegraphy." The medal was instituted in 1864 to reward "distinguished service in promoting arts, manufactures and commerce."

PROFESSOR G. ELLIOT SMITH has been elected president of the Manchester Literary and Philosophic Society.

DR. RAY LYMAN WILBUR, president of Stanford University, who has always taken particular interest in the sociological problems connected with diseases, has been elected president of the California State Conference of Social Agencies.

AT the annual meeting of the Linnean Society on May 24, Dr. A. Smith Woodward, of the British Museum of Natural History, was elected president.

CHARLES W. LENG, secretary of the New York Entomological Society and research associate in the American Museum of Natural History, has been appointed director of the Museum of the Staten Island Institute of Arts and Sciences. Mr. Leng has been interested in the natural history of Staten Island, where

he was born and lives, since boyhood. Entomologists and other naturalists, visiting New York City, can reach the museum of the institute by a pleasant half hour's sail across the bay on the Staten Island ferry.

UNIVERSITY AND EDUCATIONAL NEWS

AMONG the gifts announced at the commencement of Harvard University were the following: From the estate of Mrs. Robert D. Evans, \$15,687; one half each to the Arnold Arboretum and the Dental School. The James C. Melvin Fund, anonymous \$53,750 for tropical medicine. Anonymous gift of \$11,250 for the departments of agriculture and landscape architecture. Estate of Mrs. Charles H. Colburn, \$97,052, for the study of tuberculosis. Mrs. Winthrop Sargent, \$27,500, of which \$25,000 goes to the Blue Hill Observatory. From the Nathaniel Cannery Association, \$15,000 for studies in public health.

DR. LEROY S. PALMER, assistant professor of dairy chemistry in the college of agriculture of the University of Missouri, has been appointed associate professor of agricultural biochemistry in the college of agriculture, University of Minnesota, and dairy chemist in the Minnesota Agricultural Experiment Station. George E. Holm, Ph.D., Minnesota, 1919, has been appointed assistant professor of agricultural biochemistry and assistant agricultural biochemist in the Experiment Station. He will devote his time almost exclusively to research on the proteins.

A. F. KIDDER has resigned as professor of agronomy in the college of agriculture of the Louisiana State University to accept the position of agronomist and assistant director of the State Agricultural Experiment Station, Baton Rouge.

DR. ALBERT SCHNEIDER, of the pharmaceutical department of the University of California, will go next September to the University of Nebraska as professor of pharmacognosy and director of the experimental medicinal plant garden.

PROFESSOR H. H. CHAPMAN returns to the Yale Forest School to assume his duties as Harriman professor of forest management. He has been assistant district forester, in charge of silviculture at Albuquerque for the past two years.

At the recent commencement the following appointments were made in the department of zoology, college of liberal arts, Syracuse University: Dwight E. Minnich, Ph.D. (Harvard, '17), of Oxford, O., instructor in zoology; Harry S. Pizer, M.Sc., of Brooklyn, N. Y., assistant in zoology.

DR. FRANK A. HARTMAN, of the department of physiology, the University of Toronto, has been appointed head of the department of physiology at the University of Buffalo.

COLONEL J. G. ADAMI, F.R.S., professor of pathology, McGill University, Montreal, has been elected vice-chancellor of the university in succession to Sir Albert Dale.

PROFESSOR GRAFTON ELLIOT SMITH, professor of anatomy in the University of Manchester, has been appointed to the chair of anatomy at University College, London.

DISCUSSION AND CORRESPONDENCE

TECTONIC FORM OF THE CONTINENTS

OUR prevailing notion concerning continental mass is strictly geographic in significance. In our definition tectonics finds no place. Relation of sea and land is made causal and essential; whereas it is only accidental and trivial. The outstanding feature is a broad basin with high mountainous rim and a low sea-level interior. This is a statement of the observation of the late Professor J. D. Dana. In its larger, or telluric, aspects this definition is genetically without meaning.

In the final analysis of the major relief features of our globe the hydrosphere is for simplicity's sake left out of account. The effect then is as if the entire face of the earth were a land area. A condition is premised analogous to that of our waterless moon. Genetically the oceans serve only to obscure the tectonic essentials of relief expression.

Recent experimental reproductions, in spheroidal masses, of those broad basinal tracts that correspond to the oceanic depressions of the geoid are accompanied by results having curious significance. They point to the fact that we shall have to modify our basic conceptions concerning all the major deformations of the earth's crust.

Instead of distinguishing between continental elevations and oceanic depressions, a circumstance imposed by an unweening importance attached to the presence of the sea, a notion handed down from time immemorial, the proper discrimination to be made is between the cordilleran ridges of the continental borders and the intervening lowlands, whether above the level of the waters in the continental interiors, or beneath sea-level in the oceanic areas. On this basis the tracts which we are accustomed to designate the oceanic depressions and the sea-level interiors of the continents are arranged in the same taxonomic category. Consideration of any such datum plane as sea-level may be with full propriety entirely neglected. The meridional disposition of the continents thus comes to be readjusted as relatively narrow orographic ridges in place of broad basin-shaped plateaus.

The tectonic consideration of a waterless earth casts a new light upon the schematic form of our globe. In its logical consequences the contractional hypothesis finds expression in such figments of the imagination as the *reseau pentagonal* of Elie de Beaumont, and the tetrahedral globe of Lothian Green. To be sure the form known as the tetrahedron is of all geometric solids the one form which possesses the least volume in comparison with a given surface area, while the sphere contains the greatest bulk within the same surface; yet the collapse of the latter is not necessarily a crystallographic shape as that indicated by the former.

In the present state of our knowledge any schematic form of our earth is largely conjectural. However, it is suggested lately that in the case of a collapsing spheroid the initial tendency towards a faceted form would prob-

ably not be directly in the line of any limiting shape, as a four-sided figure, but towards something intermediate between a limiting shape and the most general form, or a figure having twelve or twenty-four faces. That the rhombic dodecahedron is possibly the real plan, if there be any, although having in nature curved surfaces, seems to be borne out by the trend of the chief mountain ranges of the world, and by the situation of the main volcanic activities at the sharp solid angles or the points where each set of faces intersect.

Viewed, then, in their telluric relations the continents are probably best regarded not as broad basins with upturned rims but as somewhat irregular, interrupted, meridianally disposed ridges. These ribs appear to be directly traceable in their genesis to released cumulative tension that depends upon the secular retardation of the earth's rotation.

CHARLES KEYES

AMERICAN ASSISTANCE FOR RUSSIAN EDUCATIONAL INSTITUTIONS

TO THE EDITOR OF SCIENCE: Revolution, war and anarchy threw Russia out of the rut of normal life. And in no phase of Russia's national life have the results been so disastrous as in public education, which can not be placed again on an adequate and normal footing without the assistance of the Allies.

Just before the war, there was adopted a plan for universal education, also for opening a number of higher institutions of learning, especially, technical and agricultural colleges. These educational institutions are open, but on account of complete lack of the supplies needed for conduct of studies and practical work of the students, and, because it has been impossible to obtain apparatus, tools, etc., from Germany and Austria whence they formerly came, it becomes necessary to conduct the studies one-sidedly and incompletely and it is difficult to expect good results from such studies.

There is only one way of obtaining such supplies for Siberia, where several higher institutions of learning have recently been opened, and that is to purchase the supplies in the United States where, at present, most of

the laboratory instruments and other technical supplies, so far as I know, are manufactured and are quite satisfactory as to quality.

The writer, who came to this country as the representative of the Ministry of Agriculture, would like to dwell upon this matter in reference to the laboratories and institutions in different branches of agriculture and experimental stations and also to throw light upon the general aspect of this question.

Equipment of the Russian educational institutions with necessary supplies is furthermore complicated by other circumstances, such as: lack of means and complete impossibility of making purchases for cash owing to very low exchange rate of the rouble at the present time. And, meanwhile, the matter of education is urgent and a way out of this difficult situation is possible only in case the American scientific and academic circles would realize that the problem of education in Russia at present is tragic, if they would have a desire to come to aid and organize such aid.

During the difficult struggle against the Bolsheviks, Siberia had an opportunity to become acquainted with and learned to appreciate the brotherly assistance of the American Red Cross in the matter of organizing hospitals and havens for refugees. The scientific educational matters as well as the work of the Red Cross may and must be outside of politics. It is sufficient to be in sympathy with a people in order to come to their assistance. And, if my American academic colleagues share this point of view and would give an impetus to this new movement in the matter of spiritual aid to Russia, then, I am firmly convinced, the Americans would organize this aid in as splendidly efficient a way as they have organized the Red Cross.

It is, however, self-evident that this aid must be given on an entirely different basis. There could be no question of charity, but simply the matter of facilitating the purchase of the necessary technical equipment by permitting purchases to be paid for in instalments.

I do not, by any means, offer my suggestion as the only feasible plan, but would only like

to indicate a plan which, it seems to me, could be realized and would suggest that it would be possible to work along the following lines: Let a competent American scientific-academic organization take up this matter. The writer can make a formal request on behalf of the Russian Ministry of Agriculture and the Ministry of Education. If the organization in question regards the matter favorably, *i. e.*, it decides that it is expedient and necessary to render those portions of Russia which had been freed from the Bolshevik domination, assistance in the purchase of the books, the instruments, the glassware and other technical equipment for institutions of learning, laboratories and experimental stations, let such an organization enter into negotiation with firms who manufacture and supply the American scientific-academic institutions with technical supplies. The purpose of these negotiations would be the arrangement of easy terms of payment on the purchases which would be necessary. Further negotiations could be carried on by an authorized person who has lists of necessary articles and who might be assisted by the Russian Economic League or some other institution which does purchasing of different commodities for Russia. In this way, it will be something like a loan in goods, such loan being made with the spiritual aid of American scientific and academic circles and with certain concessions on the part of the American firms.

It might be mentioned that such concession should prove a very good business investment, since it would be an excellent foundation for substituting American apparatus and tools for the German articles which are the only ones used in Russian schools so far. This concession would be practically an equivalent of advertising American supplies in Russian educational institutions. The very fact of equipping the Russian institutions of learning with American supplies and having the Russian instructors work with the American-made apparatus and tools clears the way for general adoption of American apparatus and tools in Russia. The habit of using a certain kind of apparatus plays a more important part than may be supposed at first sight and it seems

that the time is ripe now to introduce in Russia the habit of using the products of American genius and industry.

I hope sincerely, that the suggestion set forth in this letter may be received sympathetically by the American scientists as well as by the special manufacturing and publishing firms which might be concerned with the carrying out of such a plan. I am ready to enter into all necessary negotiations in respect to this matter and I thank in advance any one who will be kind enough to help me with advice or suggestion concerning my efforts in this direction.

N. BORODIN

FLATIRON BUILDING,
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NEW YORK CITY

SCIENTIFIC BOOKS

The Elements of Astronomy. By CHARLES A. YOUNG. Boston, Ginn & Co. 1919. Pp. x + 508.

Lessons in Astronomy. By CHARLES A. YOUNG. Boston, Ginn & Co. 1919. Pp. ix + 420.

These are new and revised editions of the most excellent text-books of the late Professor Charles A. Young. From the time this series first appeared some thirty years ago, these books have held high rank among the many that have been written. They show a wide grasp of the fundamentals of astronomy, and these fundamentals are presented to the student in a clear and comprehensive manner.

The author's presentation of the problems involved in the study of the motions of the planets is especially noteworthy. For the mathematician these motions involve the greatest complications and require the most intricate formulas, yet Professor Young places the essential facts before the student in a simple and clear manner. By the aid of a few diagrams and some apt illustrations, the fundamentals of celestial mechanics are explained, and explained so clearly that the youngest student should have no difficulty in understanding the problems and in grasping the essential facts and principles.

The present edition was revised by Miss

Anne S. Young, who retained the greater part of the original text and made such changes only as were necessary to bring it down to date. In general the changes were made with discrimination and the text shows an improvement. Astronomy, however, is not a complete science, and changes and improvements are continually being made. This is especially true of the applications of astronomy to practical matters. In some cases there have been marked improvements in the ideas and methods of thirty years ago, and too rigid an adherence to the original text on the part of Miss Young detracts from the general excellence of the revision. In the discussion of the tides, for example, there has apparently been no change, and the old theory of a world tide, originating in the Pacific and Indian Oceans, has been adhered to. No mention is made of the new theory advanced by the Coast and Geodetic Survey that the tides are purely local phenomena; that the tides of each locality originate in and are confined to that ocean basin of which the particular locality is a part; that the tides of the North Atlantic have no connection with those of the Pacific.

The "Lessons" are for beginners, the "Elements" for the more advanced students. Both books are excellent and no better text-books have yet appeared for these classes of students.

CHARLES LANE POOR

SPECIAL ARTICLES

FURTHER STUDIES IN COLLOID CHEMISTRY AND SOAP

THE following summarizes experimental findings and theoretical deductions which continue studies reported in these pages last year.¹

I

Our previous work had emphasized not only how from pure soaps and water most typical lyophilic colloid systems may be produced but in what way the chemical constitution of the soaps and variations in concentration, tem-

perature, presence of electrolytes and non-electrolytes, etc., changes the physical properties of these colloid systems. Practically all attempts to explain such changes are to-day electrical in nature. Without denying that electrical phenomena sometimes play a rôle, our newer experiments show that it may be very small or need not function at all.

Typical lyophilic colloid systems may be made of pure soaps in the practical or complete absence of all water. The pure soaps yield such colloid systems with the various absolute alcohols, benzene, toluene, chloroform, carbon tetrachloride and ethyl ether. We feel that our future definitions of lyophilic colloid systems and the understanding of their processes of swelling, gelation, syneresis, reversibility of sol and gel states, hysteresis, etc., must be expressed in the broader terms of mutual solubility. As the hope of getting all phenomena of "solution" reduced to electrical terms seems remote, the hope of getting these fundamental colloid chemical findings reduced to a similar level seems equally remote.

Of the list of effective "solvents," the alcohols have received most study. The solvation capacity of the different soaps (as measured by the maximum amount of alcohol that will be taken up to yield a "dry" or non-syneretic gel at ordinary temperatures) varies in the case of absolute ethyl alcohol for molar equivalents of the sodium soaps of the acetic series of fatty acids from practically zero in the lowermost member to over 27 liters per gram molecule in the case of sodium arachidate. When the solvation capacity of unit weights of any one soap for different alcohols is compared, it is found that this is different not only as mon-, di- or triatomic alcohols are used but different, also, for the different alcohols in any one of the series. For the monatomic alcohols, for example, the solvation capacity increases progressively and smoothly as the position of the alcohol rises in the series. A gram of sodium stearate will just form a gel at room temperature, for example, with 50 c.c. of methyl alcohol, but the same amount of the same soap will form a gel with over 132 c.c. of amyl alcohol. When sodium oleate is the soap employed all the absolute

¹ Martin H. Fischer and Marian O. Hooker, "Ternary Systems and the Behavior of Protoplasm," *SCIENCE*, 48, 143, 1918.

absorption capacities for the different alcohols lie lower, but their order remains the same

II

If we attempt to say why we obtain these typical colloid systems from such a variety of materials we may begin with the fundamental and now generally accepted conclusion that colloid systems result whenever one material is divided into a second with the degree of subdivision coarser than molecular. A suspension colloid results whenever the colloiddally dispersed phase is *not* a solvent for the "dispersing medium"; a hydrophilic or lyophilic colloid whenever the dispersing medium is such a solvent (and independently of the fact that the subdivided phase is solid, liquid or gaseous at the temperature employed). When soap is dissolved in acetone and the temperature is lowered the soap falls out as a colloiddally dispersed suspension colloid because the acetone is not soluble in the soap; but the same soap dissolved in an alcohol, toluene or carbon tetrachloride, comes out as a lyophilic colloid because these solvents are soluble in the precipitating soap.

But the physical characteristics of the ultimately resulting system are not yet explained when we have thus taken into account the mutual solubility characteristics of their phases. In any given case, as with a given soap and its "solvent," four possible results and consequently four main types of ultimate system may be foreseen. At the top exists a non-colloid, "molecular" or "ionized" "solution" of soap (soaped-solvent). For example may be cited a fairly concentrated solution of soap at a higher temperature. At the bottom is found another "solution" but of the solvent in the soap (solvated-soap). Between these extremes exist two main types of mixed systems, namely, one below the top which is a dispersion of solvated-soap in soaped-solvent, and another, above the bottom, which is a dispersion of soaped-solvent in solvated-soap. These are respectively the sols and gels about which we talk. A concentrated solution of soap in any solvent, it will at once be apparent, passes successively, on lowering of the temperature and when not too much solvent is

used, from the top of this series through the two middle zones to the bottom.

All the systems below the true solution at the top and above the true solution at the bottom are "colloid." Gel formation is characteristic of the middle zones. Such gels are "dry" anywhere below the point where enough solvated-soap falls out on lowering the temperature to yield a continuous *external* phase enclosing the soaped-solvent. Just above this point they sweat, the amount of such "syneresis" obviously increasing progressively as the amount of solvated-soap becomes inadequate to form a continuous external phase. If the "syneresis" is very great we no longer apply the term, for the syneretic liquid (soaped-solvent) now forms the continuous external phase. The colloid system is said to have remained or to have passed into the "sol" state.

Since change or rate of change in temperature (as well as other factors) affects the solubilities of the two phases in each other unequally it is obvious that the sum total of changes in any system need not be identical at any given moment and at any given temperature when the temperature is being approached from a higher level with the sum total of these same changes when the same temperature is being reached from a lower level. The attainment of equilibrium takes time and so the systems hold over the characteristics of the systems from which they came. This is the "hysteresis" of lyophilic colloid systems.

III

The effects of adding different hydroxides and different neutral salts in increasing concentration to standard soap "solutions" has received further study. In order to understand the effects observed and their explanation it is well to divide the experimental findings into three groups while keeping in mind the solubility characteristics of the pure soaps themselves in water and for water.²

1. *Soaps are formed more soluble in the dispersion medium.* The viscosity of the soap mixture regularly falls. This happens when

² See our previous paper, Martin H. Fischer and Marian O. Hooker, *SCIENCE*, 43, 143, 1918.

ammonium hydroxide is added in any amount whatsoever to a potassium or sodium soap.

2. *Soaps are formed less soluble in the dispersion medium.* This is observed when magnesium, calcium, iron or copper salts are added to a solution of sodium or potassium oleate. The systems as a whole again become more liquid though not in this instance because the soaps are better "dissolved" in the solvent but because they fall out and allow the viscosity of the pure solvent (essentially salt water) to come to the front.

3. *The change in kind of soap is negligible or absent.* This happens, for example, when a neutral potassium salt or potassium hydroxide is added to a potassium soap. Under these circumstances the most interesting of all series of changes are to be noted with increasing concentration of the added material. There is, first, an increase in viscosity which, if the amount of solvent is not too great, results in gelation, followed by a secondary liquefaction and then a progressively increasing separation of soap from the dispersion medium until it finally floats as a dry mass upon the underlying solution of salt or alkali.

If, in explanation, we do not wish to make too many violent assumptions the following seems a reasonable way out. *The fixed alkalis and the various neutral salts are hydrated in water.* As more and more salt is added the number of such hydrated particles (or their size) increases. The effect is two-fold. Through deprivation of solvent the concentration of the soap is increased while the particles of hydrated salt remain emulsified in the hydrated soap.³ *This emulsification* (with the increase in the concentration of the soap itself) *accounts for the initial increase in viscosity.* As more salt is added the hydrated salt phase attains a value which makes the particles begin to touch. The hydrated soap now becomes the internal phase and the hydrated salt the external one. This change in type of emulsion explains the secondary lique-

faction of the gel, a characteristic of these systems not previously noted so far as we are aware. More salt increases further the hydrated salt phase which now begins to separate off at the bottom while the still hydrated soap floats to the top. By adding enough salt all the water is taken from the soap which then floats as a dry layer upon the concentrated salt solution.

IV

Various incidental observations upon the reaction of soap-water systems toward indicators of various kinds have proved of importance not only for the theory of these systems but for the understanding of various biological problems, for living matter, too, as so often emphasized, is essentially nothing but a hydrophilic colloid system. The findings show how dangerous it is to assume that physico-chemical methods and opinions (such as hydrogen ion determinations) as derived from the study of the dilute solutions may, without reserve, be applied to living protoplasm.

To be sure of strictly reproducible ground materials we have always prepared our soaps by adding to each other the necessary gram equivalents of fatty acid and alkali. *Any soap as thus formed is either acid, neutral or alkaline to such an indicator as phenolphthalein depending upon the concentration of the water in the system.* Phenolphthalein added to a concentrated sodium oleate solution remains colorless, but this oleate with its contained indicator turns pink or strongly red as more and more water is added to the system. It does not suffice to say that a hydrolysis of the soap is suppressed in the concentrated solution to come to the fore in the dilute solution. It is more reasonable to say that when the water is dissolved in the soap the system is something different from that resulting when the soap is dissolved in the water. If a gel of sodium stearate is used, direct application of phenolphthalein to its fresh section shows the framework of the gel (the water-in-soap portion of the system) to remain uncolored while the soap-in-water portion of the system turns bright red.

³ Regarding the making and breaking of emulsions, see Martin H. Fischer and Marian O. Hooker, *SCIENCE*, 43, 468, 1916; "Fats and Fatty Degeneration," 29, New York, 1917.

A future communication will show how these colloid chemical facts may be used in the erection of secretory models which, like the salivary gland or kidney, yield "secretions" either more alkaline or more acid than the allegedly neutral (or even acid or alkaline) tissues.

It has proved impossible to find an editor with space available for the details of the experiments outlined above and previously reported upon. They must in consequence be brought out in a book. But since the making of such takes time, it has seemed of interest to make a preliminary report upon work which has at various times been lectured upon to different scientific audiences.

MARTIN H. FISCHER

EICHBERG LABORATORY OF PHYSIOLOGY,
UNIVERSITY OF CINCINNATI,
May 5, 1919

THE BUFFALO MEETING OF THE AMERICAN CHEMICAL SO- CIETY. III

Testing the mildew resistance of fabrics: F. P. VEITCH and S. S. LEVINE. A method has been devised for testing the mildew resistance of fabrics treated by so-called mildew-proofing processes. The method takes into consideration the important determining mold growth and is conducted in the laboratory under conditions which are highly favorable to the development of mildew and which are carefully controlled. It is briefly described as follows: Six discs about 3.5 inches in diameter are cut from the sample to be tested and soaked in running tap water for two or three days in order to wash out easily removable fungicides and fermentable matter. The damp discs are placed in petri plates containing ten to fifteen cubic centimeters of agar jelly from nutrient matter. The plates are then incubated for seven to ten days in a dark chamber at from 20° C. to 25° C. The condition of the fabric as to the color, extent and character of the growth are observed and recorded. Following this pre-inoculation period the discs are inoculated with pure cultures of several species of molds and reincubated for three weeks to a month and examined each week for mold growth. The observed conditions are rated on a scale of ten. At the conclusion of the tests the discs are washed and preserved as records. The test is a severe one

which is borne perfectly for the full period only by canvas treated by the cupra-ammonium process. Its utility has been demonstrated, however, by the fact that canvas which gives a rating of 6 or better has not mildewed on exposure to the weather at Washington, D. C., during the summer and fall months.

Testing materials for increasing the water resistance of sole leather: H. P. HOLMAN and F. P. VEITCH. To determine waterproofing value, several pieces of sole leather which are always of the same tannage and from the same section of the hide but which differ in texture are impregnated by immersing in the treating material for ten minutes at 60° C., followed by warming in an oven at 60° for fifteen minutes. Water absorption is determined by soaking in water for twenty-four hours, with periodical flexing, and weighing the wet leather after removing all excess from the surface. The leather is also weighed before treating, after treating, and in the air dry condition after testing. From these weights the quantity of treating material taken up by the leather, the actual water absorption, and the loss in weight on testing are calculated in percentages. The actual water absorption is calculated on the basis of the final dry weight. All dry weights should be made after exposing the leather to the same atmospheric humidity. Eighty samples, including practically all the commercial materials used in waterproofing sole leather, were tested by this method. Only twenty were found to waterproof sole leather sufficiently to prevent its absorbing an average of more than 35 per cent. of water under the conditions of the test. This percentage was arbitrarily adopted as a limit for satisfactory materials for increasing the water resistance of sole leathers.

Method for determining the water resistance of fabrics: F. P. VEITCH and T. D. JARRELL. In developing more effective methods of making canvas water- and mildew-resistant, and for testing for the War Department deliveries of canvas and clothing for water resistance, it was necessary to employ methods of testing that are both expeditious and indicative of the effectiveness and durability of the treatment. Modifications of the old bag or funnel and of the spray test have been devised which have proved very satisfactory in that all canvas given high ratings by these methods have been found to be water resistant during six months of outdoor exposure throughout the summer and fall. Of the two, the spray test yields possibly the most information. Neither the de-

termination of permeability to water under pressure, nor of water absorption added to the information given by the funnel and spray tests. Fabrics widely different in water resistance showed practically no difference in the quantity of water absorbed in a given time. Details of the methods, including the method of making the exposure tests, illustrations of the equipment and the scale of numerical ratings used, are given in the paper which is to be followed by other dealing with water- and mildew-proofing treatments and with the deterioration caused by such treatments on outdoor exposure.

An impact tester for solid and corrugated fiber board: E. O. REED and F. P. VEITCH. Since the usual methods of testing solid and corrugated fiber board by determining its bursting strength with a Mullen Tester was found unsatisfactory, an impact tester has been devised which closely imitates conditions which fiber board containers must meet in actual service. The results obtained are stated in terms of the height from which a 2-kilogram hammer must be dropped in order to drive a one kilogram plunger, having a spherical base of definite dimensions, through a definite unsupported area of the board. The tester should be useful in establishing impact requirements of different weights of fiber board. Results so far obtained indicate that with this tester data are obtained which are not only a measure of the bursting strength, but also of the resiliency of the board, which are the two main factors determining serviceability.

Waterproof papers for box lining and bale wrapping: F. P. VEITCH and E. O. REED. During the war there has been an increased demand for waterproof papers for box-lining and bale-wrapping purposes due especially to the fact that for overseas shipment, army and navy supplies had to be put in the most compact form and were baled whenever it was possible. Many types of wrapping papers proposed for protecting the contents of bales and boxes against moisture have been subjected to laboratory and actual bailing tests to determine the relative merits of different methods of waterproofing and the probable serviceability of different types of paper as indicated by such test. Very definite information on the most water-resistant types of wrapping paper has been secured.

Lead-coated Iron (exhibits): CHAS. BASKERVILLE. A process for coating sheet iron, iron wire and wire gauze has been worked out depending in

part upon dipping the article after the usual pickling and washing into a solution of antimony chloride, thence through a suitable supernatant flux into a bath of molten lead or antimony lead, withdrawing and quenching in oil. Shingles, 10 × 16 ins., of 28 g. iron thus coated, painted and unpainted, have been exposed to the weather in a roof test for two years and eleven months and show 100 per cent. efficiency, that is no rust spots. The shingles may be bent at various angles without cracking the coating and exposing the iron. It is superior to and less expensive than tin plates. Shingles exposed near the exits of sulphuric acid chambers soon show rust, due probably to condensation of nitrous and nitric acids, whose solvent action on lead is well known. Thin sheet iron thus coated is easily pressed into desired shapes, for example, hub caps for motor vehicles, the lead acting as a lubricant. The pressed article lends itself well to nickel plating and subsequent burnishing. Wire gauze (chicken wire), thus lead coated, is quite as good as the galvanized article and cheaper to produce. Heavy steel pipe, 8-inch for pipe lines, was not successfully coated for practical purposes, due to irregularities in the surface and the abrasions produced in the surface and its softer coating, when chains and tongs were applied in screwing the joints together. Where iron in juxtaposition to lead is exposed to aerated water (practical conditions) through incomplete coating (pinholes) or abrasion of the lead, the iron rusts more rapidly as it is electro-positive to lead. This is also true for tin-coated iron, while the opposite is true for galvanized iron. However, for some purposes lead-coated metal possesses advantages, especially in expense. Cast iron requires a preliminary pickling in hydrofluoric acid, when it may be coated by the process given, but not perfectly, due to the irregularities of surface. However, this thin coating serves as a satisfactory binding agent for thick layers of lead cast thereon, for example in filter press plates. This was found to be true also for the rough drilled interior of shells; electrolytically deposited lead, with subsequent burnishing, has been found superior for lead coating the interior of gas shells requiring such protection.

Reinforced lead (exhibits): CHAS. BASKERVILLE. Lead in large sheets or heavy pipe flows. Various devices, as numerous straps for sheets, serving as walls in acid chambers, frequently placed supports for pipes, walls of masonry holding sheet lead linings in large petroleum refining tanks, and so forth, are utilized to reduce the sagging.

Vacuum pipes of lead must be of unusual thickness and great weight to prevent collapsing. Iron and steel pipe with lead lining is extensively used, the lead protecting the iron or steel, but the latter also prevents bulging of the lead when the necessary pressure is applied to move the liquids thus transported. These difficulties have been overcome in large part by reinforcing lead with iron or steel gauze in much the same manner that glass is reinforced by wire netting. Wire netting of various sizes of mesh is given a coating of lead or lead-antimony, as described in another paper, and is imbedded in sheet lead of a thickness about one quarter greater than desired, this is then rolled while cold. Reinforced lead in sheets 5 ft. X 6 ins., have been made. They may be bent or cut as desired. Joints have been burned together or finished without leaving any iron exposed. Skeleton frameworks of metal lined with reinforced lead sheeting serve as tanks and other containers without sagging. Eight-inch pipe made of one quarter inch thick reinforced lead withstood a pressure of eight times that of an eight-inch pipe made of seven eighths inch thick lead before collapsing.

Utilization of asphaltic base acid sludge from petroleum: CHAS. BASKERVILLE. Instead of cooking the asphaltic base residue with the mixed sulphuric acid to carbonization and then burning the mass mixed with coal as fuel, the present practise, the cooking is carried on at a much lower temperature and for much shorter time. The acid mass separates into three layers, lighter residues being on top, and the heavy sulphuric acid being at the bottom. These are drawn off, leaving the middle portion of asphaltic material containing 15-25 per cent. of sulphuric acid. The proper amount of dry slaked lime is thoroughly mixed with this asphaltic base in a suitable mill. The heat of neutralization is sufficient to fuse the asphalt, which mixed with the calcium sulphate produced, flows into suitable containers, and solidifies on cooling. The mass, which contains 20 to 40 per cent. of calcium sulphate, may be melted and applied where desired, as in the common practise. Time tests have demonstrated the value of the material thus produced for waterproofing (wood and concrete), roofing, road material and as a protective covering for metals. The process is covered by U. S. Patent 1,231,985.

Equilibrium studies on the Bucher process: JOHN B. FERGUSON and P. D. V. MANNING. A quantitative study of the deleterious effects of carbon monoxide in the furnace gases upon the

cyanide conversion at two temperatures, 946° and 1,000° C. The experimental methods employed and results obtained will be presented.

Design for electrically heated bomb for ammonia synthesis (lantern): R. O. E. DAVIS and H. BRYAN. The bomb consists of a nickel-chromium-iron alloy of sufficient strength to withstand several hundred atmospheres pressure. It is electrically heated by a specially devised heater. The method of insulating the walls is shown as are also the method of introducing the catalyst container, and the electric leads.

Purification of compressed gases in testing catalysts for ammonia synthesis (lantern): R. O. E. DAVIS. The method used in removal of moisture, carbon monoxide, carbon dioxide and oxygen is described and the type of purification chamber used is shown. It is pointed out how necessary it is to have very pure gas in the tests.

Preparation of nitrogen and hydrogen mixture by decomposition of ammonia (lantern): R. O. E. DAVIS and L. B. OLMSTEAD. A mixture of hydrogen and nitrogen in the proportion of three to one is obtained by decomposing liquid ammonia. This is accomplished by passing the ammonia over heated iron shavings and steel wool. The decomposition is almost complete with the apparatus described, furnishing about 1.3 cu. ft. of gas per minute.

Explosion of gases used in ammonia synthesis: R. O. E. DAVIS. A description is given of an explosion which occurred in a cotton filter used to remove oil and water spray from mixed nitrogen and hydrogen at a hundred atmospheres pressure.

Some chemical needs of the vegetable oil industry: DAVID WESSON.

CHARLES L. PARSONS,
Secretary

(To be continued)

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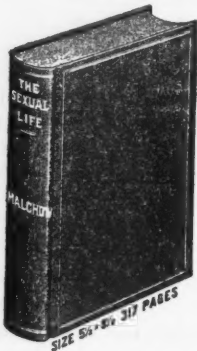
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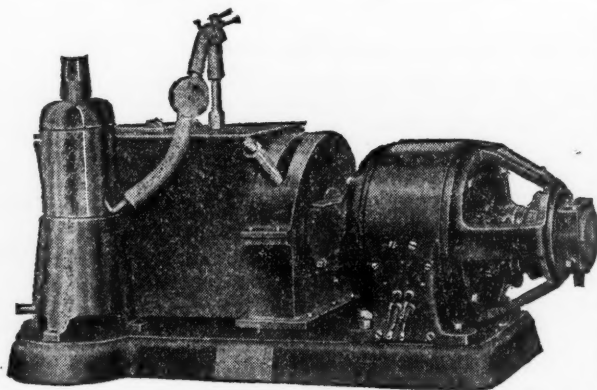
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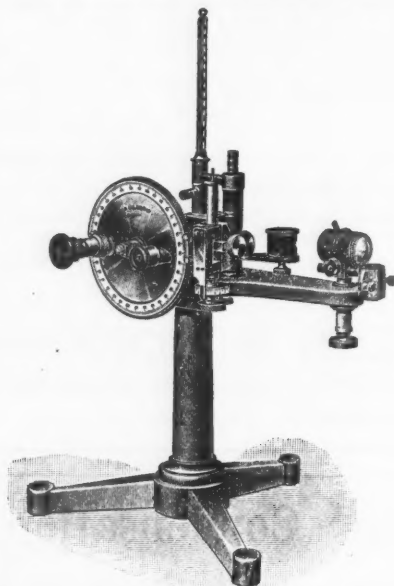
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The first and second year classes are limited to 100 students. Women are admitted. Application should be presented before July 1st, as on that date the selection of the entering class will be made.

About 125 students can be accommodated in the third and fourth year classes and applications for admittance on advanced standing will be considered from students who have made excellent records in other "Class A" medical schools.

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Clinical instruction is given in the University Hospital on the campus with 400 beds and the immediately adjoining Philadelphia General Hospital with 1600 beds. The fundamental branches are taught in the Hare Laboratory of Chemistry, the combined Laboratories of Pathology, Physiology and Pharmacology, and the Laboratory of Hygiene and Bacteriology.

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Information concerning courses in the recently organized Medico-Chirurgical College Graduate School of Medicine of the University of Pennsylvania, which includes as a unit the former Philadelphia Polyclinic Hospital and Polyclinic Graduate School of Medicine, can be obtained from the Dean as well as information about courses leading to the degree of Doctor of Public Hygiene (Dr. P.H.) and courses in Tropical Medicine.

TUITION

Undergraduate study, \$200 annually; fees for graduate and special courses on application.

The annual announcement, application blanks and other information may be obtained by application to the

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University of Pennsylvania

Philadelphia, Pa.

University of Georgia

MEDICAL DEPARTMENT

Augusta, Georgia

ENTRANCE REQUIREMENTS

The successful completion of at least two years of work including English, Physics, Chemistry, and Biology in an approved college. This in addition to four years of high school.

INSTRUCTION

The course of instruction occupies four years, beginning the second week in September and ending the first week in June. The first two years are devoted to the fundamental sciences, and the third and fourth to practical clinic instruction in medicine and surgery. All the organized medical and surgical charities of the city of Augusta and Richmond County, including the hospitals, are under the entire control of the Board of Trustees of the University. This agreement affords a large number and variety of patients which are used in the clinical teaching. Especial emphasis is laid upon practical work both in the laboratory and clinical departments.

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For regularly matriculated students courses are arranged leading to the degree of Doctor of Public Health, Doctor of Science in Hygiene and Bachelor of Science in Hygiene. The details in regard to the requirements for matriculation in these courses are described in the catalogue of the School which will be forwarded upon application.

A certificate in Public Health may be awarded to qualified persons after one year of resident study.

Persons desiring to take one or more courses not as applicants for a degree may enter as special students on approval of the Faculty.

For further information address the Director of the School of Hygiene and Public Health, Johns Hopkins University, 310-312 West Monument Street, Baltimore, Maryland.

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The annual announcement will be sent on application to The Director, Marine Biological Laboratory, Woods Hole, Mass.

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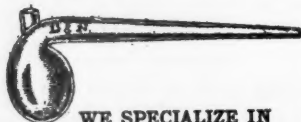
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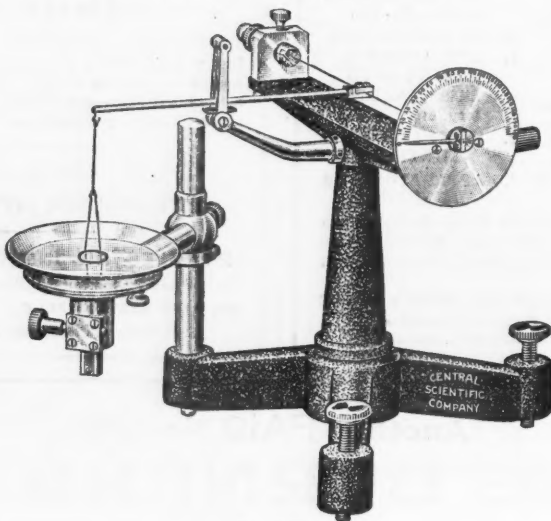
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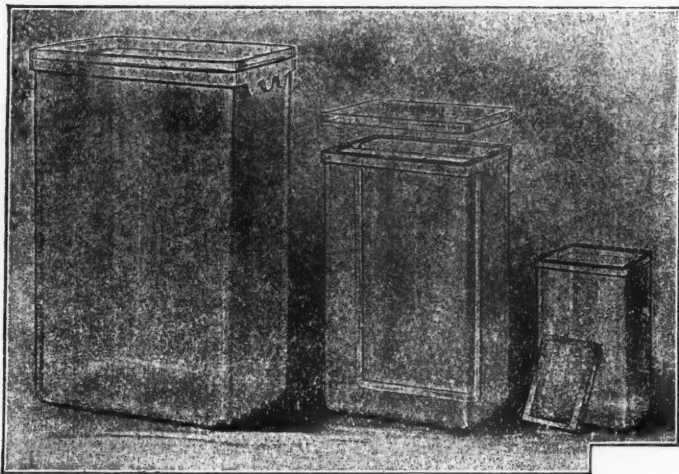
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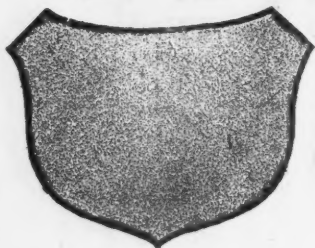
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